

Contemporary trends in the surgical management of aortic valve disease

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ABSTRACT:

Introduction: Aortic valve pathology carries a high mortality burden. Its incidence is growing in proportion to the continuous ageing of the population. Surgery remains the gold standard in the treatment of severe aortic valve disease.

Methods: We performed a retrospective analysis of the University Hospital Center Zagreb's cardiac surgical database from 2009 to 2020, focusing on surgical aortic valve replacement (SAVR). We dichotomized patients with respect to the date of their surgical procedures into two eras. Group 1 included patients operated from 2009-2014, whereas Group 2 included patients operated on from 2015-2020.

Results: A total of 1012 SAVRs were identified during the study period. The procedural volume over the two identical 6-year time periods increased in the latter era from 413 to 598. When comparing groups 1 and 2, we have observed an increase in the number of patients with diabetes (19% vs. 26%, $P=0.015$) and coronary artery disease (14% vs. 18%, $P=0.099$). The composite risk assessment score increased significantly from 3.0 ± 2.4 to 3.2 ± 2.7 , $P=0.023$. Despite an increase in the comorbidity burden of the targeted patient population, the periprocedural mortality remained the same (2.1% vs 2.5%, $P=0.835$). The per-patient averaged volume of transfused packed red blood cells decreased from 839 ± 954 to 614 ± 821 ml, $P<0.001$. An increase in the proportion of tissue valve implantations in comparison to mechanical prostheses was also noted in the present era (58% vs 68%, $P=0.001$).

Conclusion: Despite an increasingly more complex patient population referred for SAVR in the contemporary era, the results have remained excellent. The introduction of transcatheter methods should measure up to the surgical standard.

KEYWORDS: aortic valve, surgery, outcomes

SAŽETAK:

SUVREMENI TRENDOVI U KIRURŠKOM LIJEČENJU BOLESTI AORTNOG ZALISTKA

Uvod: Patologija aortnog zaliska nosi visoku smrtnost. Njegova incidencija raste proporcionalno kontinuiranom starenju stanovništva. Kirurgija ostaje zlatni standard u liječenju teške bolesti aortnog zalistka.

Metode: Proveli smo retrospektivnu analizu kardiokirurške baze podataka KBC-a Zagreb od 2009. do 2020. godine, s naglaskom na kirurški nadomjestak aortnog zalistka (SAVR). Dihotomizirali smo pacijente s obzirom na datum njihovog kirurškog zahvata u dvije skupine. U skupinu 1 uključeni su pacijenti operirani od 2009.-2014., dok su u skupinu 2 uključeni pacijenti operirani od 2015.-2020. **Rezultati:** Ukupno je identificirano 1012 SAVR-a tijekom razdoblja istraživanja. Proceduralni volumen tijekom dva identična šestogodišnja vremenska razdoblja povećao se u kasnijoj skupini s 413 na 598. Uspoređujući grupe 1 i 2, uočili smo porast broja pacijenata sa dijabetesom (19% prema 26%, $P=0,015$) i koronarne arterijske bolesti (14% naspram 18%, $P=0,099$). Kompozitni rezultat procjene

rizika značajno se povećao s 3,0 +/- 2,4 na 3,2 +/- 2,7, P=0,023. Unatoč povećanju komorbiditeta ciljane populacije pacijenata, periproceduralni mortalitet je ostao isti (2,1% naspram 2,5%, P=0,835). Prosječni volumen transfuziranih crvenih krvnih stanica po pacijentu smanjio se s 839 +/- 954 na 614 +/- 821 ml, P<0,001. Povećanje udjela implantacija tkivnih zalistaka u usporedbi s mehaničkim protezama također je zabilježeno u današnje vrijeme (58% naspram 68%, P=0,001)
Zaključak: Unatoč sve složenijoj populaciji pacijenata koji se upućuju na SAVR u suvremeno doba, rezultati su ostali izvrsni. Uvođenje transkateterskih metoda trebalo bi biti u skladu s kirurškim standardom.

KLJUČNE RIJEČI: aortna valvula, kieurgija, ishodi

INTRODUCTION

As many as 3-4% of the adult population have at least moderate aortic valve disease in Western countries (1). The prevalence is likely to rise in the future, mirroring the trend of an increasingly older general population in developed countries (1). Indications for surgical aortic valve replacement (SAVR) include severe symptomatic aortic stenosis (AS) in the setting of normal flow and normal or reduced ejection fraction (LVEF) (2). Low flow/low gradient AS is a class IIa indication for SAVR. Asymptomatic AS may also be an indication of surgery in the setting of left ventricular dysfunction or symptoms unmasked at stress test. The latter may be challenging as many patients deny symptoms and unconsciously modify their daily routines in order to prevent the occurrence of symptoms (1). Patients with symptomatic severe aortic regurgitation should be referred for SAVR without delay (2). Asymptomatic patients are also candidates for surgery in the setting of reduced LVEF and end-diastolic dilation of the left ventricle greater than 70 mm (2). Both untreated severe AS and AR carry an ominous prognosis, and these patients should promptly be referred for an aortic valve intervention. While SAVR remains the most commonly performed procedure, some patients with aortic regurgitation are also candidates for aortic valve repair (3,4). Aortic valve pathology is a mechanical problem, requiring a mechanical solution. Despite the introduction of transcatheter approaches for the treatment of severe aortic valve pathology, SAVR remains the standard of care (2,5,6). Additionally, it caters to patients requiring both mechanical and tissue prosthesis (7). The choice of an optimal prosthesis is based on a complex algorithm that includes the patient's life expectancy, comorbidities, ability to be anticoagulated and lifestyle choices (8). The patient's preference is critical in the decision-making process, since both types of valve prosthesis have unique sets of complications that may occur in the future. This is true, regardless of the planned type of aortic valve procedure. The conventional approach includes a full median sternotomy. Minimally invasive approaches, however, are gaining popularity in the surgical community (9,10,11) and are nowadays routine in larger cardiac surgical centers. Management of severe aortic valve pathology should be tailored to the individual patient and should be the subject of discussion within a multidisciplinary heart team.

METHODS

Study design

We performed a retrospective analysis of the University Hospital Center Zagreb's cardiac surgical database from January 1, 2009 to December 31, 2020. During the observed study period a total of 1012 surgical aortic valve replacements were performed at our tertiary academic center. Patients with aortic valve repair, concomitant coronary artery interventions, or in whom SAVR was part of a multivalvular procedure were excluded from the study. Additionally, all pediatric patients were excluded. The local Institutional Review Board approved the study. Written informed consent was waived due to the retrospective nature of the study. Individual medical records were reviewed for demographic, clinical, laboratory and transfusion requirement data. Patients were dichotomized into two groups based on the date of surgery. Group 1 was comprised of patients operated on from January 1, 2009 to December 31, 2014, whereas those operated on from January 1, 2015 to December 31, 2020 formed group 2. The primary outcome measure was blood product utilization across the study and control populations, as well as trends in risk assessment across the two eras.

Surgical technique

Conventional aortic valve replacements are performed through a full midline sternotomy, while minimally invasive SAVRs are performed via a limited sternotomy with a "J" extension into the third or fourth intercostal space. Management of cardiopulmonary bypass (CPB) or myocardial protection strategies did not differ between the surgical approaches. Technical aspects of the procedure included aortic valve excision followed by annular debridement on an arrested heart during CPB. The prosthesis was then anchored into a supraannular or intrannular position, depending on the type of valve prosthesis. All patients underwent intraoperative transesophageal echocardiography in order to evaluate the function of the newly placed aortic valve prosthesis.

Statistical analysis

The Shapiro-Wilk test was used to determine whether a dataset followed a normal distribution. Continuous data are presented as mean values ± standard deviation or medians with their respective interquartile ranges. The Mann-Whitney U test or the Stu-

dent's t-test were used for testing continuous data. Categorical variables and endpoints are presented as absolute numbers with percentages and were compared across groups using 2×2 contingency tables. Measures of association were derived from Fisher's exact test. The data were processed using the IBM SPSS Statistics software package (version 20.0; Somers, NY, USA).

RESULTS

Baseline patient characteristics

Of the entire surgical volume at our tertiary academic center, 1012 patients had isolated aortic valve replacements. We have observed a significant rise in the number of performed SAVRs during the latter six-year period. The total number of treated patients from 2009 to 2014 was 413, while 598 patients were similarly treated

from 2015 to 2020, indicating a 45% increase in total volume. Patients in *group 1* were younger (66 ± 12 vs. 68 ± 10 , $P=0.080$) and less likely diabetic (19% (79/413) vs. 26% (154/598), $P=0.015$). The absolute prevalence of coronary artery disease (not requiring surgical intervention) was higher in group 2, albeit not reaching statistical significance (Table 1). The prevalence of bicuspid aortic valve morphology decreased over time (25% (102/413) in group 1 vs 18% (107/598) in group 2, $P=0.009$). The measure of operative risk used in our study was the European System for Cardiac Operative Risk Evaluation (EuroSCORE) II. It was designed to specifically predict operative mortality in the cardiac surgical arena. The composite EuroSCORE II score increased in the latter era (3.0 ± 2.4 vs. 3.2 ± 2.7 , $P=0.023$). Baseline patient characteristics are summarized in Table 1.

Table 1. Baseline demographic and clinical profiles of the study population.

Patient characteristics	Group 1 (2009-2014), n=413	Group 2 (2015-2020), n=598	P
Age (years)	66±12	68±10	P=0.08
Male (n/%)	249 (60)	352 (59)	0.696
Body mass index (kg/m ²)	29±5	30±5	NEMA
Hypertension (n/%)	326 (79)	477 (80)	0.752
Diabetes mellitus (n/%)	79 (19)	154 (26)	0.015
Chronic pulmonary obstructive disease (n/%)	32 (8)	56 (9)	0.427
Coronary artery disease (n/%)	57 (14)	107 (18)	0.099
Smoking history (n/%)	62 (15)	138 (23)	0.002
Peripheral vascular disease (n/%)	14 (3)	20 (3)	1.0
Cerebrovascular disease (n/%)	43 (10)	77 (13)	0.277
Creatinine clearance (mL/min)	73±26	87±37	<0.001
Endocarditis (n/%)	11 (3%)	16 (3%)	1.0
Bicuspid aortic valve (n/%)	102 (25)	107 (18)	0.009
Myocardial ischemia (min)	74±24	73±24	0.151
Extracorporeal circulation (min)	108±43	106±41	0.739
Preoperative hemoglobin (g/L)	131±26	133±18	0.144
EuroSCORE	3.0±2.4	3.2±2.7	0.023

Outcomes

Despite an increase in the aforementioned risk assessment score, overall mortality did not increase over the studied period (9 (2.1%) in Group 1 vs. 15 (2.5%) in Group 2, $P=0.835$).

A trend worth noting was that the proportion of patients receiving bioprosthetic valves over mechanical prosthesis increased significantly over the studied period (Figure 1, 58% (241/413) vs. 68% (408/598), $P=0.001$). The incidences of reoperations for bleeding, new pacemaker requirements or perioperative renal replacement therapy were similar between the groups (Table 2). Conversely, we have seen a reduction in the incidence of post-operative atrial fibrillation (139 (34%) vs 154 (26%), $P=0.007$) and blood product utilization. The volume of transfused packed red blood cells decreased significantly (839 ± 954 vs. 614 ± 821 , $P<0.001$), as did the volume of fresh frozen plasma (395 ± 628 vs. 324 ± 601 , $P=0.005$) over the studied period. Transfusion requirements for platelets and fibrinogen remained unchanged across the two eras. Perioperative outcomes are detailed in Table 2.

DISCUSSION

The present data, to the best of our knowledge, reflects the largest published single center series of SAVR patients in Croatia. We have shown that the increasing complexity of cardiac surgical patients in the contemporary arena did not translate into worse outcomes. Given the poor prognosis of untreated aortic valve pathology, we are pleased to report that patients were referred for surgery more commonly than was the case in the past. This is clearly illustrated by our data, which showed that the procedural volume increased by 45% in the latter era in comparison to the first 6-six year period. This favorable trend in patient referral for aortic valve interventions is further amplified by the fact that a certain percentage of patients with severe aortic stenosis were treated by transcatheter aortic valve implantations (TAVI). These non-surgical patients were not captured by our data. Historically, TAVI candidates were recruited among patients thought to have a prohibitively high surgical risk. We are witnessing a paradigm shift as the proportion of patients treated with TAVI is increasing worldwide and increas-

Table 2. Outcomes of surgical aortic valve replacement in different eras

<i>Patient outcomes</i>	<i>Group 1</i> (2009-2014), n=413	<i>Group 2</i> (2015-2020), n=598	<i>P</i>
30-day mortality (n%)	9 (2.1)	15 (2.5)	0.835
ICU stay (days)	2.5±2.8	2.2±3.6	0.328
Postop. AF (n%)	139 (34)	154 (26)	0.007
Reoperation for bleed (n%)	14 (3)	13 (2)	0.242
New pacemaker (n%)	13 (3)	10 (2)	0.136
Mechanical ventilation (hours)	8 [6,12]	7 [6,11]	0.139
New dialysis (n%)	7 (2)	3 (1)	0.101
Blood product utilization			
Packed red blood cells (ml)	839±954	614±821	<0.001
Fresh frozen plasma (ml)	395±628	324±601	0.005
Platelets (doses)	0.5±2.0	0.6±3.1	0.937
Fibrinogen (g)	0.1±0.5	0.3±1.1	0.294

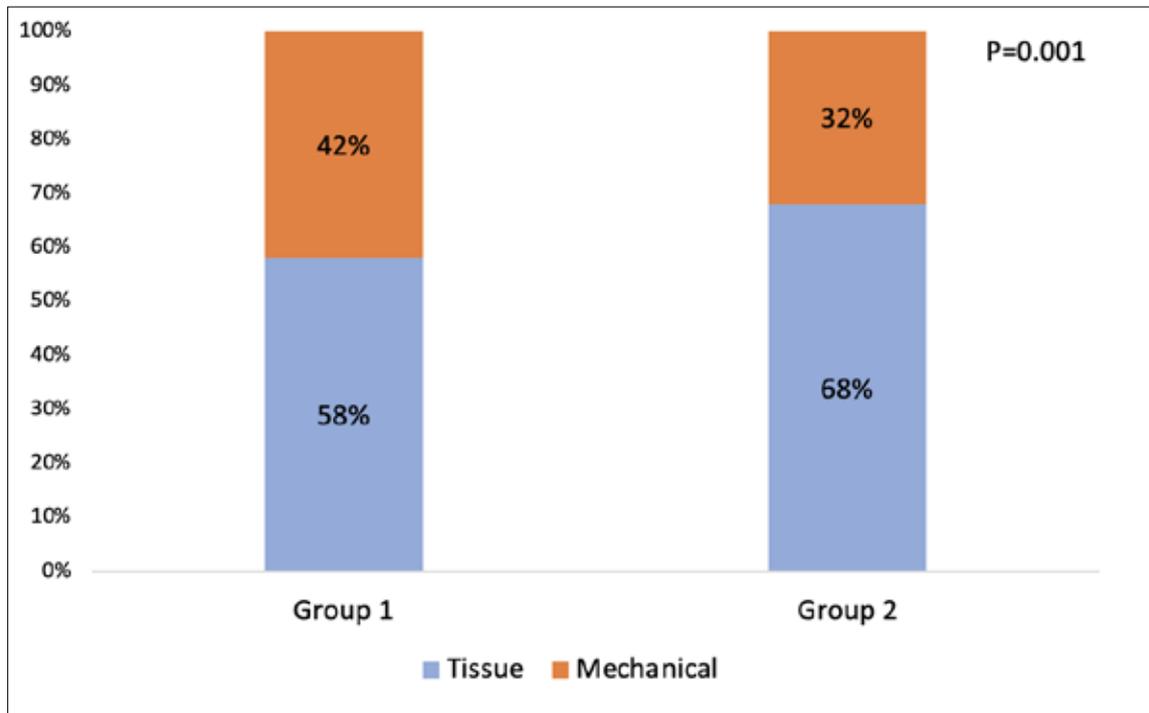


Figure 1. Temporal dynamics of utilization of tissue and mechanical prostheses in the aortic position

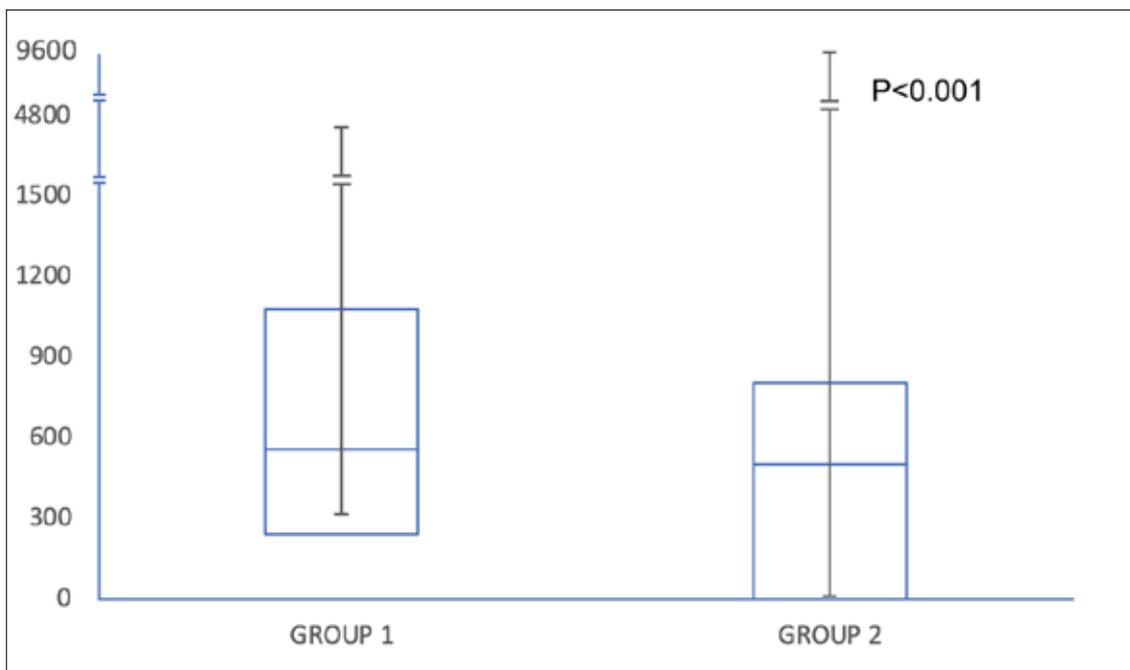


Figure 2. Box and whisker plot of the volume of transfused packed red blood cells averaged per patient. Shown are minimum and maximum values, as well as median, first and third quartiles.

ingly lower risk patients are being recruited (12,13,14). Surgery, however, remains the standard of care, as it offers reproducible long-term results and is much less likely to be associated with paravalvular leaks, new onset third degree AV block and vascular access related complications; all of which burden TAVI (15). The two technologies should be complementary and not competing, as they should target different patient populations (13).

Our present data shows that the population of patients referred for surgery are older and have an ever increasing comorbidity burden. These trends are likely to continue given the demographic profile of developed countries. A clear preference for tissue valves was seen in the recent time period. This is in line with the cardiac surgical practice in Western countries. This is driven in part by the ageing patient population, but also by lifestyle choices made by the patients themselves. Furthermore, the risk

of reoperations has decreased in the modern surgical experience which diminished reluctance of placing valves known to have an expiration date. Finally, the latest line of management of degenerated tissue valve prostheses is valve-in-valve TAVI (16). All these factors act in concert to make tissue valves more attractive options than in the earlier cardiac surgical experience.

Despite a higher risk patient population, several quality control metrics have improved over the latter period. Namely, blood product consumption has been reduced across the board, indicating that advancements in surgical technique as well as blood conservation strategies have been implemented into routine practice. In summary, we found that notwithstanding the higher risk profile of patients with severe aortic valve pathology in the contemporary era, SAVR remains associated with excellent results and remains the standard of care.

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